CNTT-E-149

BASIC ELECTRICITY AND ELECTRONICS

STUDENT HANDOUT

NO. 312

SUMMARIES PROGRESS CHECKS FOR MODULES

33-4 & 34-1

JUNE 1984

SUMMARY
LESSON 4

Field Effect Transistors

Impedance matching problems, resulting from the bipolar transistor's low input impedance, have for years lead scientists to search for a solid state device that retains the high input impedance of the vacuum tube. The result is the field-effect transistor, or FET. Whereas the bipolar transistor uses bias current to control conductivity, the FET is voltage-controlled, much like a vacuum tube.

Figure 1 shows how one type of FET, the junction type, or JFET, is constructed.

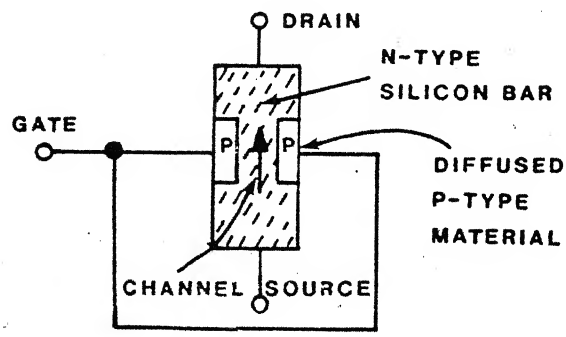


Figure 1

JFET

The three elements of the JFET operate like the familiar transistor and vacuum tube elements, "gate" like base and grid, and "source" and "drain" like emitter/collector and cathode/plate, respectively. The main body of this type of JFET is a bar of N-type material, connecting source and drain elements. Deposits of P-type material on either side are connected to form the gate element and create a narrow "channel" in the bar.

The key to FET operation is the effective cross-sectional area of the channel, which can be controlled by variations in the voltage applied to the gate. This is demonstrated in the figures that follow.

Figure 2 shows how the JFET operates in a zero gate bias condition.

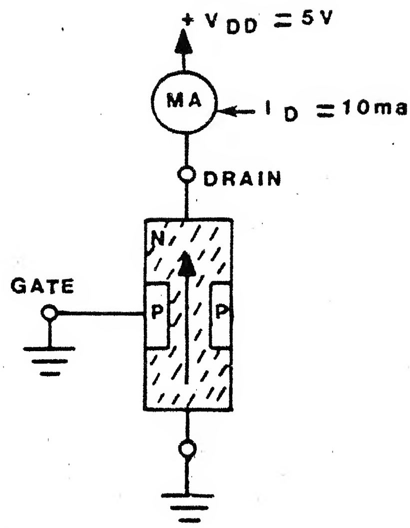


Figure 2

JFET OPERATION-ZERO GATE BIAS

With the gate terminal tied to ground (0 volts), a drain supply (V_{DD}) of 5 volts gives a drain current (I_D) reading of 10 mA. In this condition, the bar represents a resistance of about 500 ohms.

In Figure 3, a small reverse bias is applied to the JFET's gate.

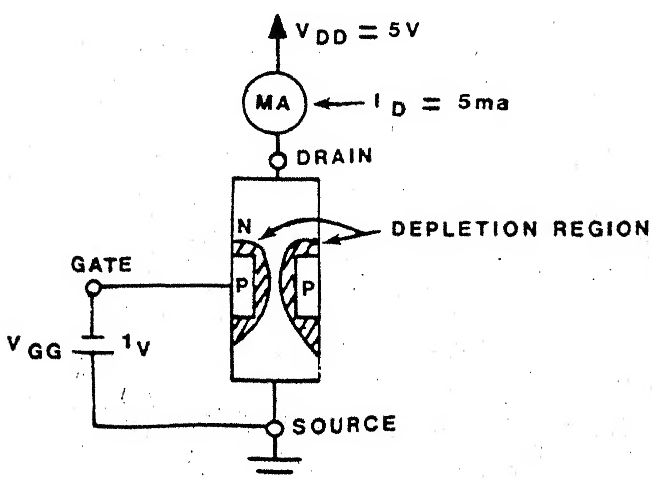


Figure 3

JFET OPERATION - REVERSE BIAS

One negative volt (V_{GG}) applied to the gate causes a reverse bias condition at the PN junction of the JFET. The resulting "depletion region" reduces the effective cross-sectional area of the channel, thus increasing source-to-drain resistance (to about 1 K Ohms) and decreasing current flow as shown.

The high gate input impedance of the JFET under reverse gate bias conditions can be seen by connecting a microammeter in series with V_{GG} as shown in Figure 4.

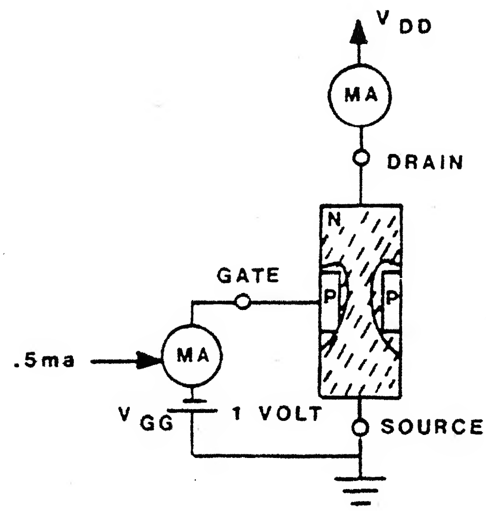
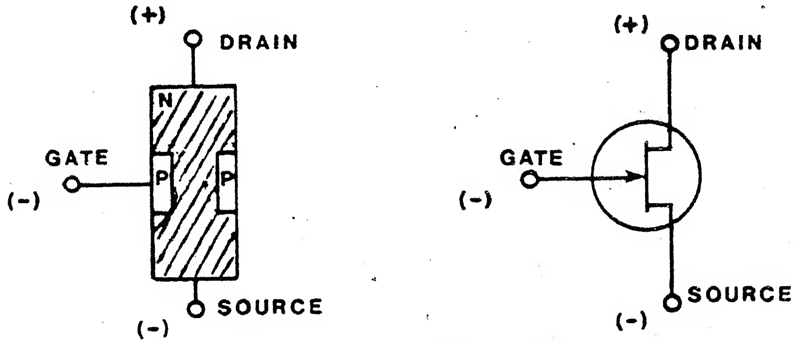


Figure 4

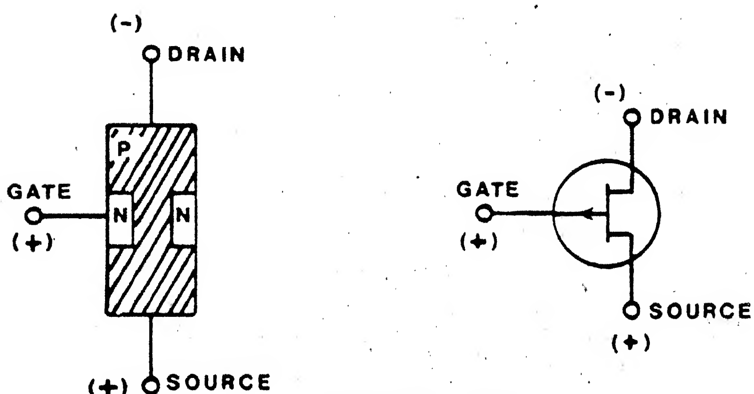
JFET INPUT IMPEDANCE

The very small amount of current flow (.5 microamps) results in a gate input impedance of about 2 megohms. By contrast, a bipolar transistor with a forward biased base-emitter junction, would have an input impedance of 1000 ohms or less.

JFETS can be either N-channel type, as shown in the above example, or P-channel type. Operation, bias voltages, and schematic symbols for the two types are compared in Figure 5. Note the bias voltage potentials are reversed for the two JFET types, just as for bipolar transistors.



N-CHANNEL JFET



P-CHANNEL JFET

Figure 5

SYMBOLS AND PICTORAL WITH BIAS VOLTAGE-JFETS

Figure 6 demonstrates the operation of an N-channel JFET in a basic common-source amplifier circuit.

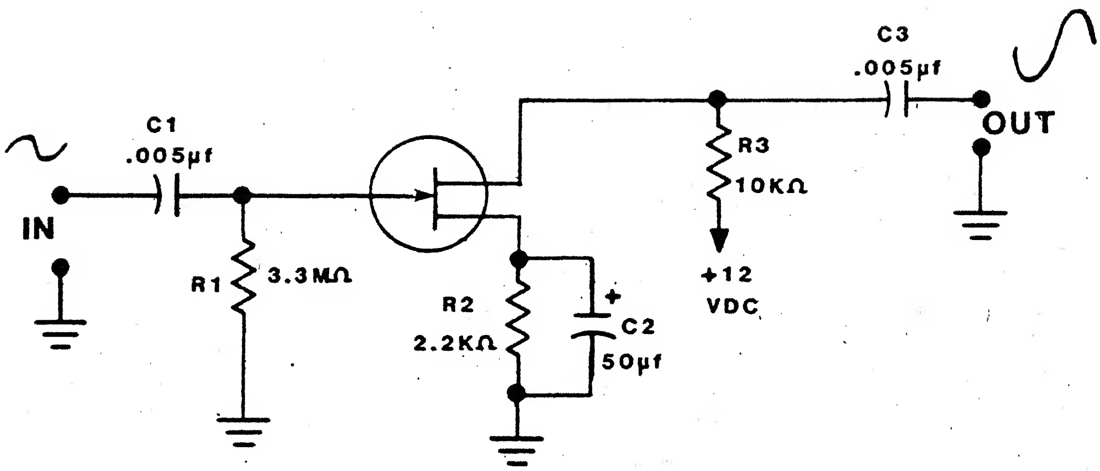


Figure 6

FET COMMON SOURCE AMPLIFIER

Circuit characteristics include high input impedance and a voltage gain of about 10 (20 db.). The function of components and the 180° phase shift are similar to those in common-cathode VT and common-emitter transistor circuits. The reason for the phase shift here is the effect of the input signal on the JFET's gate bias. On the positive alternation, reverse bias is decreased. This increases the channel's effective cross-section, decreases source-to-drain resistance, and increases current. The result is an increase in the voltage drop across R3 and a decrease in drain voltage. On the negative alternation, reverse gate bias is increased, and circuit action is reversed.

An FET with even higher input impedance than the JFET is the "metal oxide semiconductor field-effect transistor" or MOSFET. Its extremely high input impedance, 10 to 100 million megohms (10^{13}-10^{14} ohms), will not load down preceeding circuits and makes the MOSFET an extremely efficient input device.

Figure 7 shows how one type of MOSFET, the N-channel type, is made.

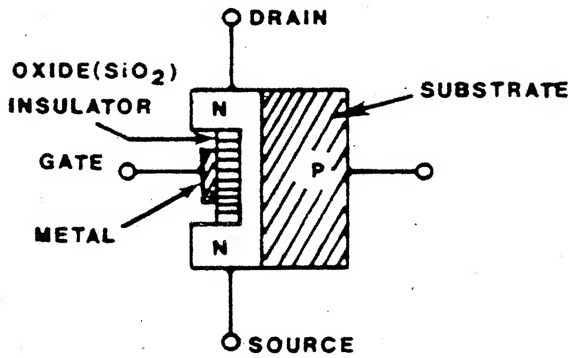


Figure 7

N CHANNEL MOSFET CONSTRUCTION

The MOSFET is a four-element device. Source and drain elements are connected by a "channel" of N-type material just as in an N-channel JFET. The channel material forms a PN junction with the "substrate" material. Although biasing the substrate element permits control of the MOSFET's gain characteristics, often the substrate terminal is connected directly to the source terminal, and the biasing capability is not used.

The gate element is made of metal and is electrically insulated from the source-drain channel by a layer of silicon dioxide (SiO_2). This total insulation results in the MOSFET's extremely high input impedance and gives rise to another common name for the device: "insulated gate field effect transistor," or IGFET.

MOSFETs can be N-channel or P-channel, and single-gate or dual-gate. Schematic symbols for dual-gate MOSFETs (only) are show in Figure 8.

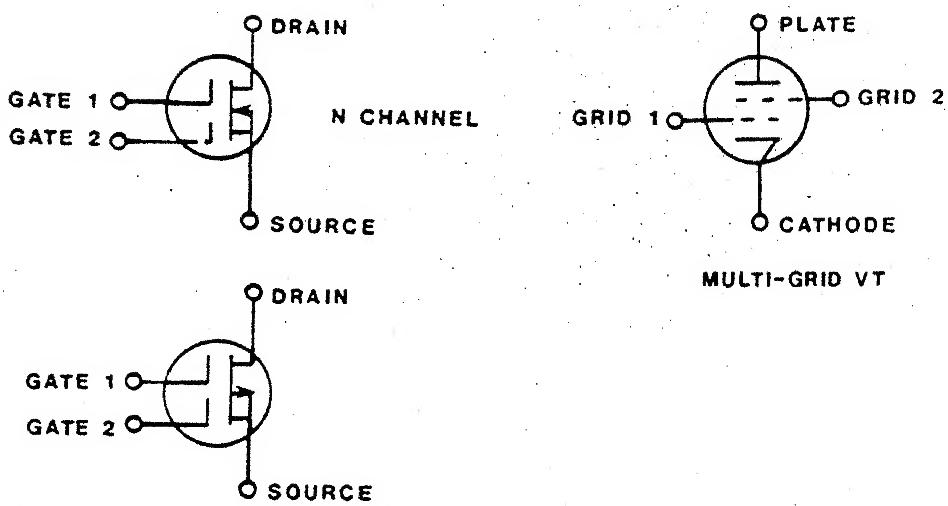


Figure 8

DUAL-GATE MOSFETS

As the figure shows, the gates are comparable to the grids in a multigrid VT. Either gate can control conduction independently, making the dual-gate MOSFET ideal for applications involving two separate signals (for example, AFC-controlled amplifiers).

To avoid accidental damage from static electricity, replacement MOSFETs come packaged with their leads shorted together with a shorting spring. This spring must not be removed until after the MOSFET is installed. A complete list of handling precautions for MOSFET devices is shown in Figure 9.

NOTICE

SPECIAL HANDLING OF MOS DEVICES

The MOS metal oxide semiconductor devices have a fairly high input resistance making them subject to damage from charges of static electricity through improper handling. The thin layer of oxide can be damaged from discharges of static electricity or improper handling in or out of circuit. The damage may be apparent immediately or may show up only after a short operating time. To avoid possible damage, the following procedures should be followed when handling or testing these devices.

1. The use of synthetic clothing such as nylon should be avoided as this will generate static charges. Dry weather (relative humidity less than 30%) also tends to increase static buildup.
2. Keep the leads of the device in contact with a conducting material or shorted, when inserting or removing from the circuit.
3. A wrist strip with a 1 megohm resistor in series to common ground should be worn by the technician when inserting, removing or testing MOS devices.
4. Do not remove or insert an MOS device with the power to the circuit or test instrument "ON".
5. Do not apply or inject test signals into the circuit when an MOS device is used with the circuit power "OFF".
6. Do not turn the circuit power "ON" with an MOS device removed from the circuit. Charges can build up causing possible damage when the device is replaced in the circuit.
7. Soldering iron tips, metal bench tops, test equipment and tools should be grounded to a common ground along with the chassis of the set being serviced.
8. Soldering guns should not be used in MOS circuits. AC line leakage from the gun tip could cause damage to an MOS device.
9. Do not apply heat for longer than 10 seconds or closer than 1/16 of an inch to any MOS device when soldering. Use of a heat sink is recommended to prevent damage to the device.
10. Use the lowest wattage soldering iron possible when removing or inserting MOS devices on printed circuit boards.

Figure 9

MOSFET PRECAUTIONS

Some MOSFETs have protection diodes built in, back to back, designed to limit transient voltage without causing distortion. Even so, it is best to observe all the above precautions when working with any type of MOSFET equipment.

Some common FET base diagrams are shown in Figure 10.

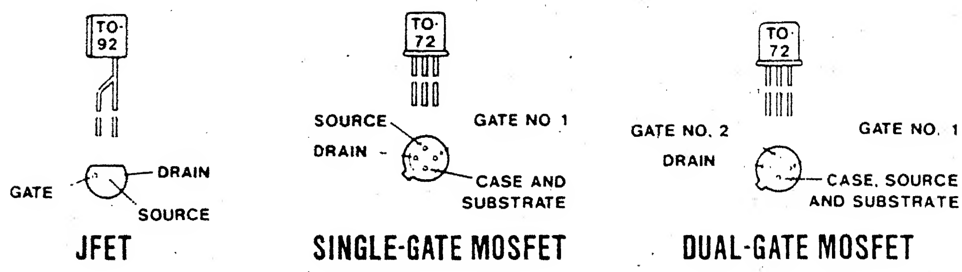


Figure 10

FET BASE DIAGRAMS

Pin arrangements for FETs are not standardized. For accurate identification of leads, a data book should be used. Signal tracing or signal injection methods can be used to locate faulty FET stages. Voltage measurements using a high impedance voltmeter are recommended. An ohmmeter should not be used, since ohmmeter battery voltages vary widely and may easily exceed maximums permitted between FET elements.

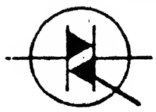
AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE LESSON TEST. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL OR MOST OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULT WITH THE LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

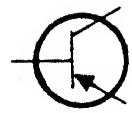
PROGRESS CHECK

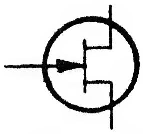
LESSON 4

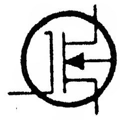
Field Effect Transistors

1. Which of the following symbols represents a JFET?

a. 

b. 

c. 

d. 

2. A P-channel JFET has a solid bar made of (N/P) type material and a gate made of (N/P) type.

3. In an N-channel JFET, a decrease in negative voltage applied to the gate will cause the cross-sectional area of the channel to (increase/decrease), the source-to-drain resistance to (increase/decrease), and current flow through the JFET to (increase/decrease).

4. When "pinchoff" gate voltage is reached in the operation of a JFET, the depletion region is (large/small), channel resistance is (high/low), and drain current is (increased to maximum/reduced to zero).

5. Rank the following devices in terms of the highest to lowest input impedance: JFETs, MOSFETs, and bipolar transistors.

highest input impedance ____________________

next highest ____________________

lowest ____________________

6. What type of MOSFET is represented by this schematic symbol?

a. dual-gate, N-channel
b. single-gate, N-channel
c. dual-gate, P-channel
d. single-gate, P-channel

7. In MOSFETs, the gate material is made of

   a. N-type material
   b. P-type material
   c. silicon oxide (SiO_2)
   d. metal

8. The high input impedance of a MOSFET is possible because there is (a PN junction/total electrical isolation) between the gate and the (substrate material/source-drain channel).

9. When, if ever, should the shorting ring on a replacement MOSFET be removed?

   a. Just before installation.
   b. Just after installation.
   c. Never.

10. FET circuit measurements should be made using a (low/high) impedance (ammeter/voltmeter/ohmmeter).

CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY AND FEEL READY, PROCEED TO THE LESSON TEST. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL OR MOST OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULT WITH THE LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

SUMMARY
LESSON 1

Introduction To Linear Integrated Circuits

Linear Integrated Circuits (linear IC's) are devices that integrate (combine) discrete (single) components into one package.

Most linear IC's are amplifiers. Their outputs will be proportional to their inputs. The internal circuitry is complete with very few required external components. Feedback networks, compensation networks, and LC tanks are added where needed.

The size of the IC is made up mostly of packaging materials; the actual circuit is a paper-thin wafer of silicon called the substrate (see Figure 1).

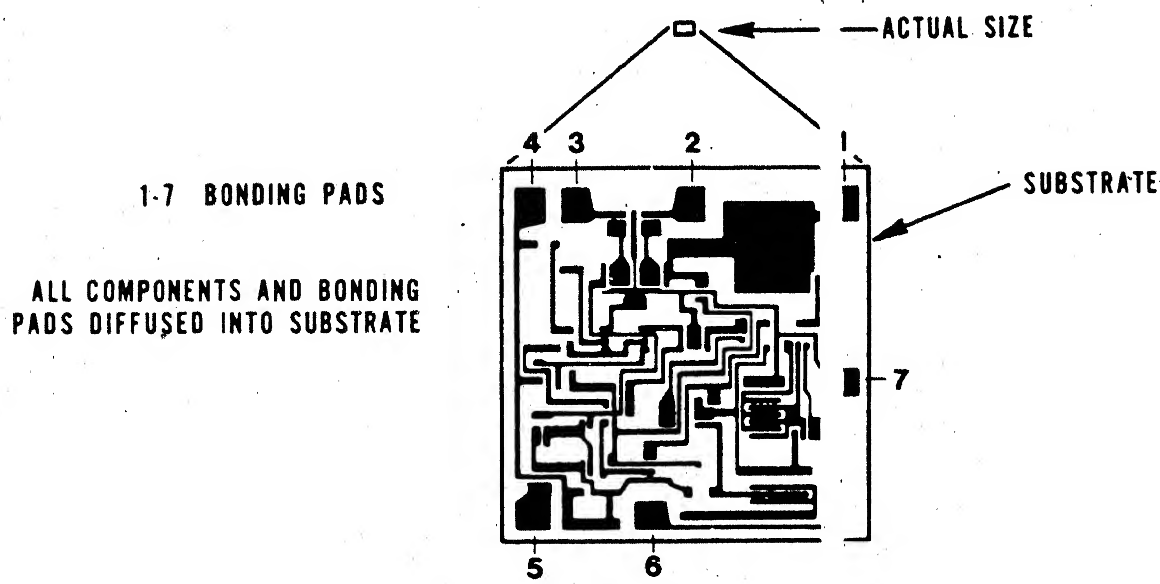


Figure 1

MAGNIFIED VIEW OF AN IC CHIP

The circuit's components are formed by a diffusion process (forcing molecules of other materials into the silicon). The completed circuit is called an "IC Chip". The IC chip is then mounted in a rugged package, like those shown in exploded views in Figure 2.

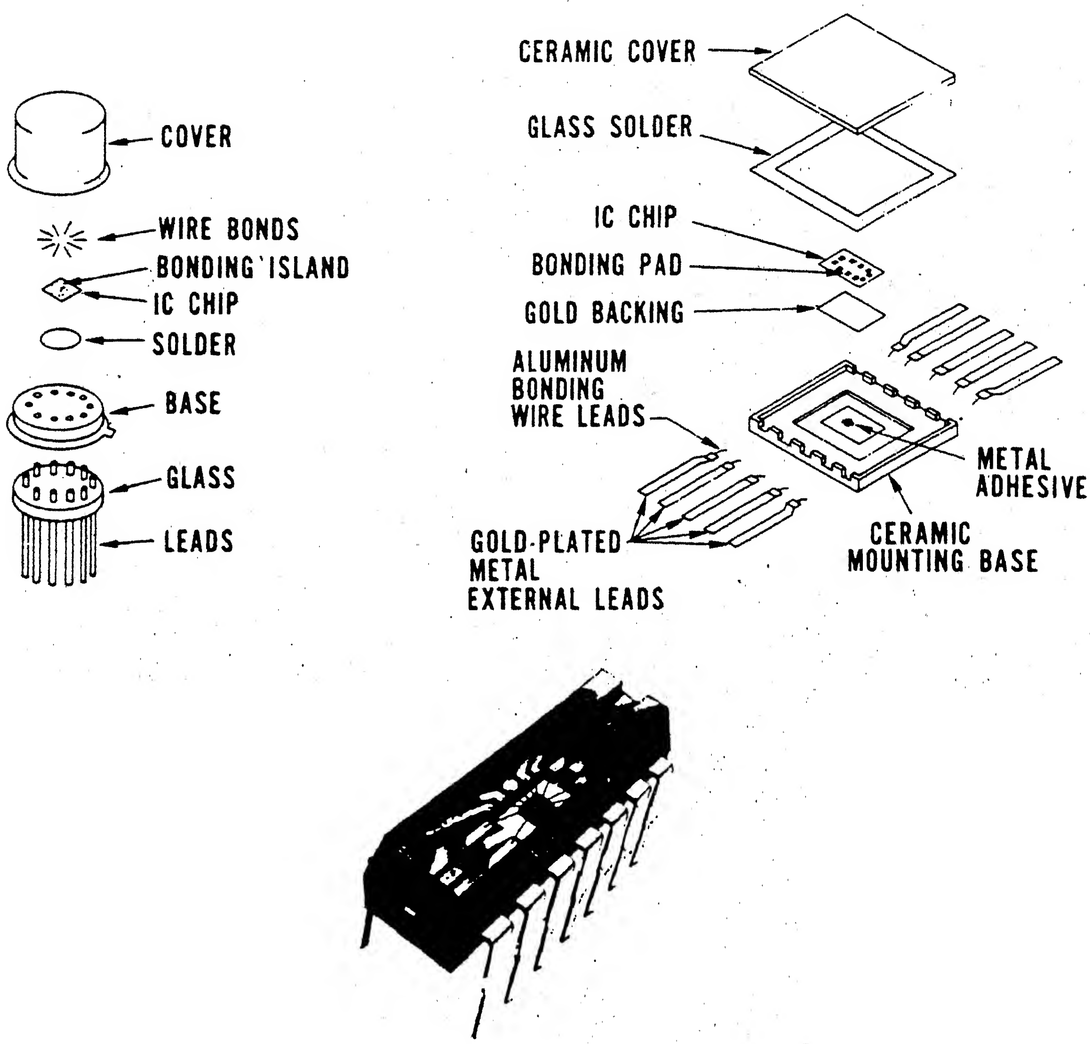


Figure 2

VARIOUS IC PACKAGES

The IC chip is soldered or cemented to a base and fine gold or aluminum wires are bonded to pads on the IC chip as shown in Figure 3.

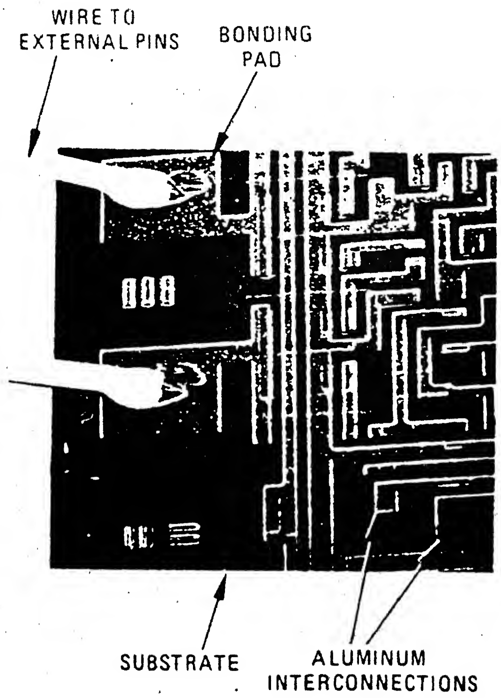


Figure 3

IC LEAD BONDING

The bonded wires are attached to the external pins, the cover is installed, and the IC package is then hermetically sealed. A hermetic seal is a seal that will not allow air, dust, or moisture to pass.

The result is a small, rugged device (see Figure 4).

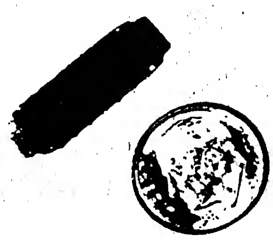


Figure 4

IC RELATIVE SIZE

Even though installed IC's are very rugged devices, they may be damaged while being handled. One of the things that can destroy an IC circuit is the static electricity that builds up on your body. To prevent static electricity from damaging the IC, ground yourself for a couple of seconds before handling the IC. An IC's shipping wrapper is made of a material designed to protect the IC from static electricity. Therefore, you should keep an IC in its shipping wrapper until you are ready to install it in a piece of equipment.

An IC may be mounted by soldering it onto a printed circuit board. The pads on the board should be spaced to accept the IC, but sometimes the IC leads do not line up with the holes in the pads. When this problem occurs, you must carefully bend the IC leads to make them line up properly. To do this you should use <u>two</u> small needlenose pliers: one to support the IC's leads, the other to make the bend (see Figure 5).

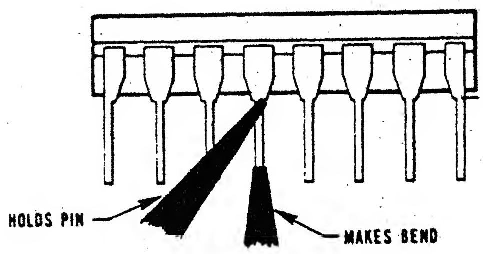


Figure 5

STRAIGHTENING IC LEADS

You must be careful not to bend a lead where it enters the IC as you do not want to break the hermetic seal. If this seal did break, the IC circuit might eventually short out from dust and moisture which could enter through the break.

Plug-in type IC's are attached to a printed circuit board by plugging them into an IC socket (see Figure 6).

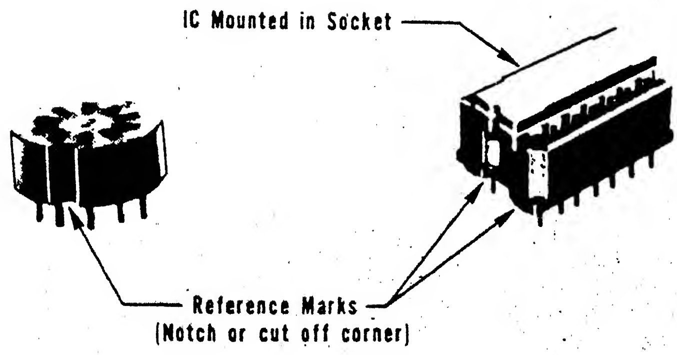


Figure 6

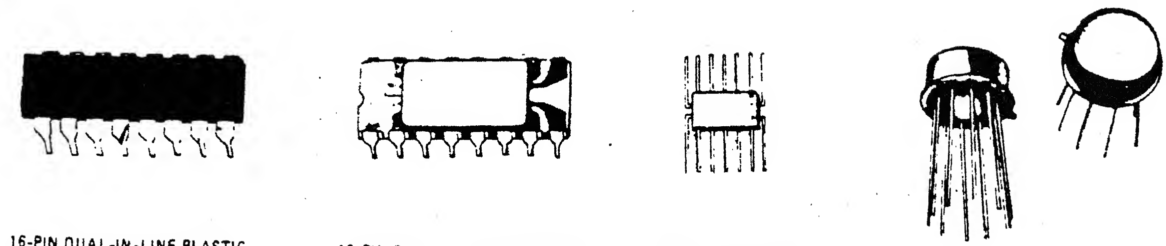
IC SOCKETS

To remove an IC from its socket, the equipment must first be deenergized. Removal is accomplished through the use of an IC removal tool called a DIP puller or package puller. If this tool is unavailable, grasp the IC between your thumb and forefinger and gently rock the IC out of the socket.

To put an IC into a socket, first make sure the pins line up with the socket's holes. If they don't, line up the leads by bending them with the two needle-nose pliers. Next, line up the reference mark on the IC (a notch, dot, impression, hole, or tab) with the socket's reference mark (a notch or cut off corner). Then, with the IC's leads lined up with the socket's holes, and the equipment deenergized, hold the IC between your thumb and forefinger and gently rock it into place.

One last handling precaution: Be carfeul not to drop or strike an IC; either the hermetic seal or one of the fine internal connecting wires may be broken.

IC's are manufactured in various package shapes (see Figure 7).



16-PIN DUAL-IN-LINE PLASTIC PACKAGE (DIP)

16-PIN DUAL-IN-LINE CERAMIC PACKAGE (DIP)

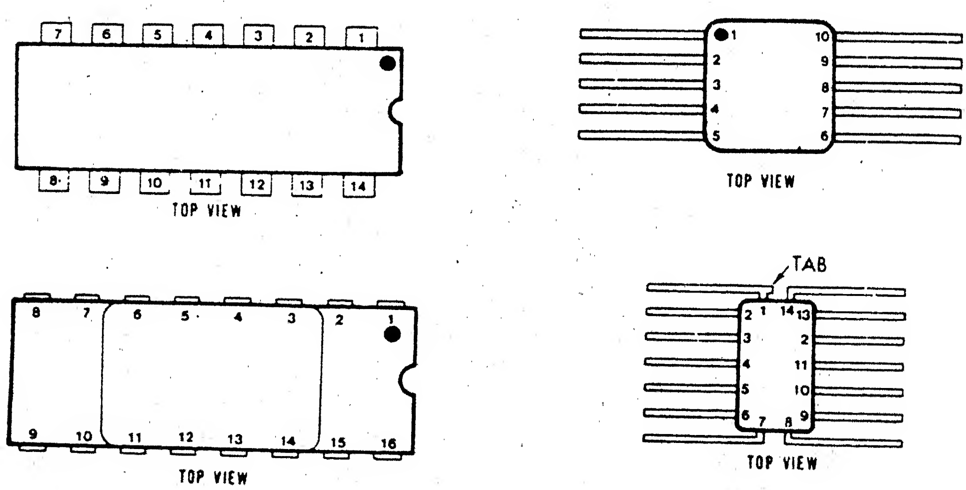
14-PIN FLAT PACK

10-PIN TO-5 CAN

Figure 7

IC CASE STYLES

Each IC has a reference mark. The dual-in-line package or DIP (both plastic and ceramic) and the flat pack will have a notch, dot or impression on the package. When viewed from the top, pin 1 will be the first pin in a counter-clockwise direction directly next to the reference mark. Pin 1 may also be marked directly by a hole or notch in it or a tab on it (in this case pin 1 is the counting reference). When viewed from the top, all other pins are numbered consecutively in a counterclockwise direction from pin 1 (see Figure 8).



DIP Packages

Flat Pack Packages

Figure 8

IC PIN NUMBERING

The TO-5 can has a tab for the reference. When numbering the leads you must view the TO-5 can from the bottom. Pin 1 will be the first pin in a clockwise direction from the tab. All other pins will be numbered consecutively in a clockwise direction from pin 1 (see Figure 9).*

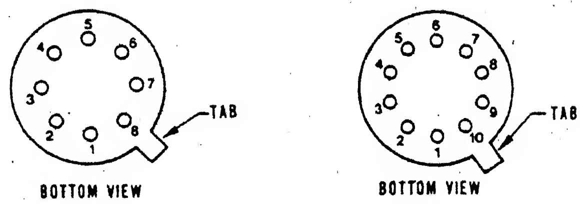


Figure 9

IC PIN NUMBERING

The schematic symbol for a linear IC is a triangle (most common) or a rectangle, as shown in Figure 10.

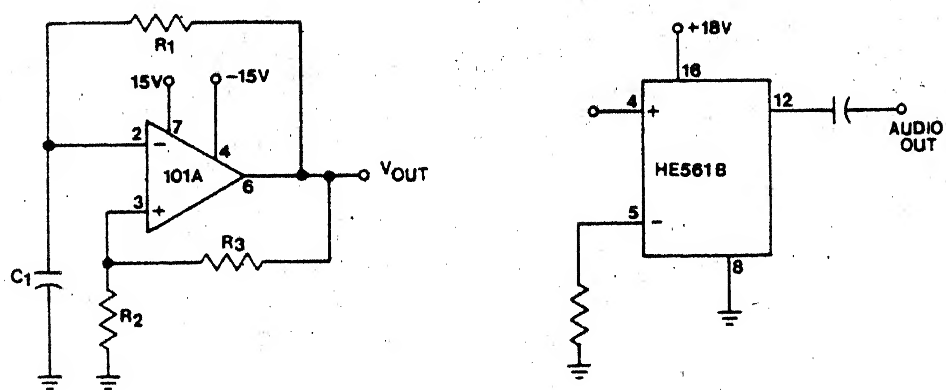


Figure 10

IC SCHEMATIC SYMBOLS

The IC's type number will be printed in the middle of the circuit symbol (101A, HE 561 B). The pin numbers will be printed outside the schematic symbol. The (+) and (-) in the triangle or rectangle indicate a non-inverting input (+) and an inverting input (-). These inputs plus the outputs and power supply connections are the only pin functions that are identified. To find the function of the other pins you must use a data sheet.

* Although this is the accepted standard, there are exceptions.

A data sheet may be just a schematic of the IC's internal circuitry with the pin functions labeled (see Figure 11).

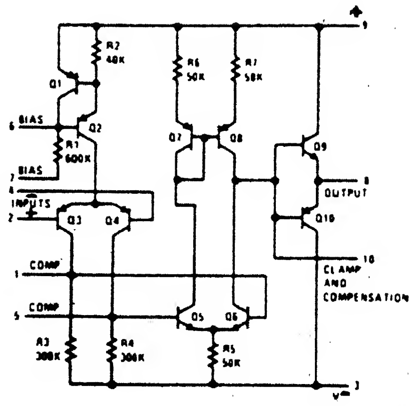


Figure 11

LH0001 SCHEMATIC DIAGRAM

The data sheet may also be a Manufacturer's Data Sheet as shown in Figure 12 on the next page. This data sheet is for a type of linear IC called an operational amplifier.

LH101 LH201 OPERATIONAL AMPLIFIER

FOR AMPLIFIERS, VOLTAGE COMPARATORS, LOW DRIFT SAMPLE AND-HOLD

Features

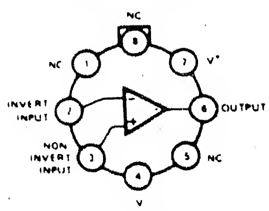
- Low Offsets and Temperature Drift
- Internal 30 pF Capacitor for Frequency Compensation
- Operation from ±5 to ±20 Volt Power Supplies
- Low Current Drain, 1.8 mA at ±20 Volts Typical
- Continuous Short-Circuit Protection
- No Latch Up When Common Mode Range Is Exceeded
- Same Pin Configuration as 709 Amplifier

Description

The LH101/LH201 is stable for all feedback configurations, even with capacitive loads, with no external compensation capacitors. Low power dissipation permits high voltage operation across the full temperature range.

PIN CONFIGURATIONS

Metal Can Package

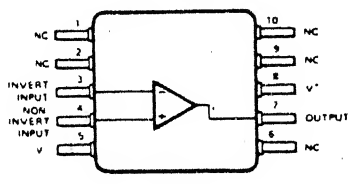


TOP VIEW

NOTE: PIN 4 CONNECTED TO CASE

ORDER NUMBERS: LH101H OR LH201H
SEE PACKAGE 1

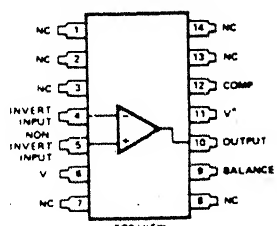
Flat Package



TOP VIEW

ORDER NUMBERS: LH101F OR LH201F
SEE PACKAGE 4

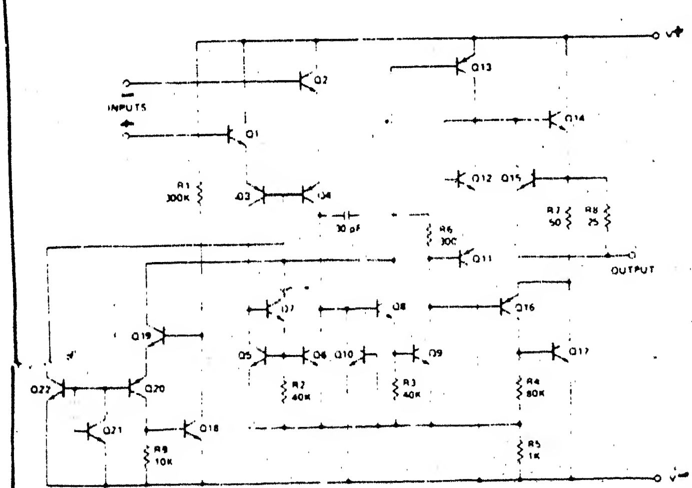
Dual-In-Line Package



TOP VIEW

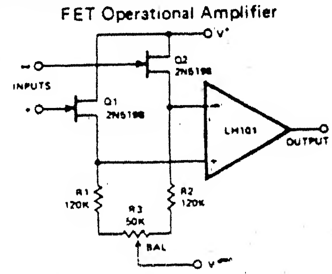
ORDER NUMBERS: LH101D OR LH201D
SEE PACKAGE 11

SCHEMATIC DIAGRAM

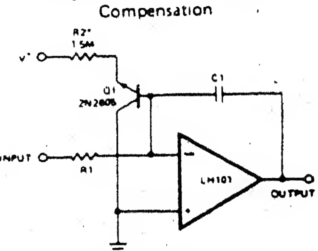


TYPICAL APPLICATIONS

FET Operational Amplifier



Integrator with Bias Current Compensation



*SELECT FOR ZERO INTEGRATOR DRIFT

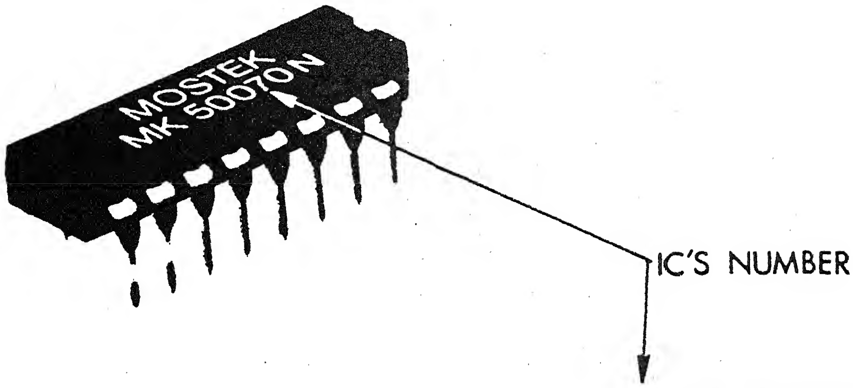
Reprinted by permission of Siliconix Incorporated. *NC - not connected internally

Figure 12

IC DATA SHEET

The manufacturer's data sheet will have either the pin configurations section, a schematic diagram, or both.

The required data sheets will be supplied with the equipment manuals. To select the correct data sheet for an IC, simply match the IC's type number, printed on the IC package or in the IC's circuit symbol, to the data sheet's type number (see Figure 13).



PRELIMINARY

MK 50070 N

CMOS Oscillator and Divider

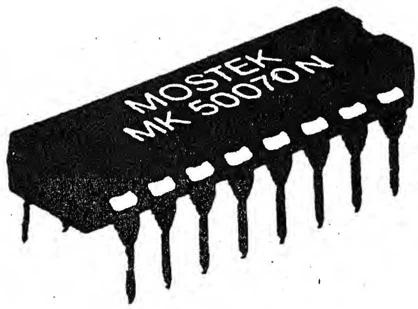
MOSTEK

FEATURES:

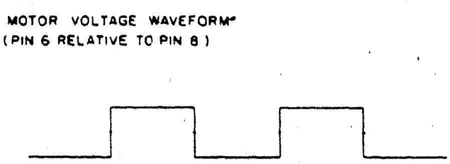
- Low Power Dissipation
- 4-18 Volt Operating Range
- Internal Zener Regulation
- Internal Oscillator

DESCRIPTION:

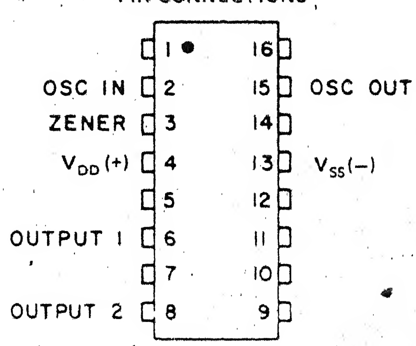
The MOSTEK 50070 circuit is an oscillator and divider circuit for specialized applications. An external quartz crystal determines the oscillator frequency and the chip divides this frequency by 49152. The output is buffered by a 4 transistor bridge.



MOTOR VOLTAGE WAVEFORM



PIN CONNECTIONS



Special Products

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Figure 13

IC DATA SHEET

The information covered in this lesson applies to all ICs. ICs require a little more care in handling than transistors, but once installed in a circuit board they are very rugged and can operate for years without circuit failure.

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE LESSON TEST. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL OR MOST OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULT WITH THE LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

PROGRESS CHECK
LESSON 1

Introduction To Linear Integrated Circuits

1. Integrated circuits replace (only one/many) component(s).

2. A linear IC produces an output signal that can be ____________________ the input signal.

   a. an amplified version of
   b. in phase with
   c. 180° out of phase with
   d. any of the above

3. The hermetic seal on an IC will not protect it from

   a. moisture.
   b. static electricity.
   c. dust.

4. The shipping wrapper (will/will not) protect an IC from static electricity.

5. When bending the leads of an IC you (do/do not) need two needlenose pliers.

6. When removing or installing an IC, the equipment containing the IC (must/need not) be deenergized to prevent damage to the IC.

7. Before an IC is installed into its socket, its reference mark must be ____________________ the sockets reference mark.

   a. lined up with
   b. one pin in a counterclockwise direction from
   c. lined up at the opposite end from
   d. one pin in a clockwise direction from

8. The abbreviation "DIP" means "____________________ Package".

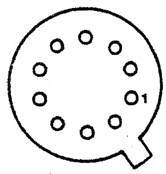
   a. Durable Integrated
   b. Dual-In-line
   c. Differential Integrated
   d. Discrete Integrated

9. When viewed from the top, the pins of the DIP and flat pack are numbered consecutively in a (clockwise/counterclockwise) direction from the reference mark.

10. When viewed from the bottom, the pins of the TO-5 package are numbered consecutively in a (clockwise/counterclockwise) direction from the reference mark.

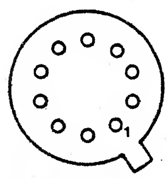
11. Which illustration shows the correct labeling of pin 1 on the TO-5 package viewed from the bottom?

a.



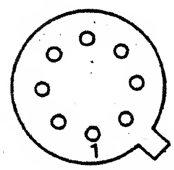
BOTTOM VIEW

b.



BOTTOM VIEW

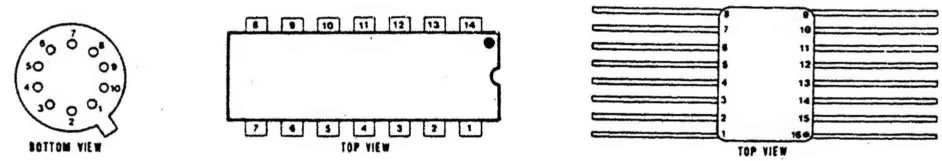
c.



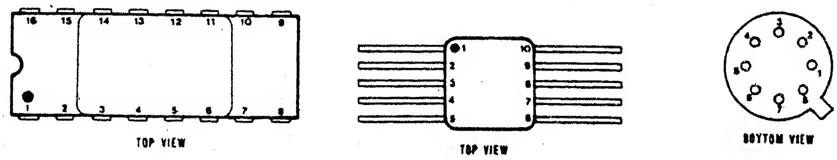
BOTTOM VIEW

12. In which of the following set of illustrations are the leads of the IC packages labeled correctly.

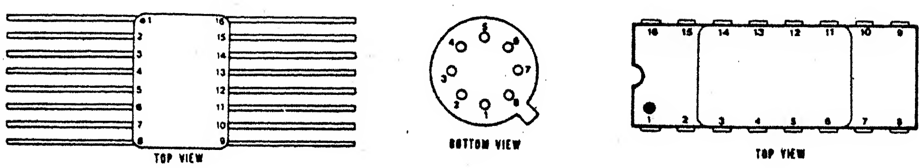
a.



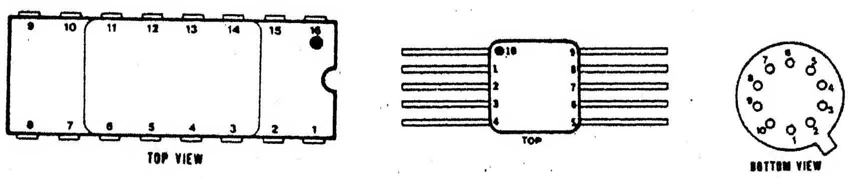
b.



c.



d.



13. In an IC's schematic symbol, its type number will appear (in the middle/ on the outside) of the symbol.

14. Refering to this data sheet, pin 8 of the TO-5 package is the ___________ connection.

a. + Vcc
b. output
c. NC
d. ground

LINEAR INTEGRATED CIRCUITS

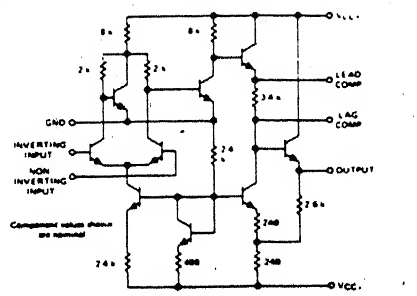
TYPES SN52702A, SN52702, SN72702
GENERAL-PURPOSE OPERATIONAL AMPLIFIERS

BULLETIN NO DL S 7311460 MARCH

SN52702A features

- Open-Loop Voltage Amplification . . . 3600 Typ
- Designed to be Interchangeable With Fairchild μA702A
- CMRR . . . 100 dB Typ

schematic



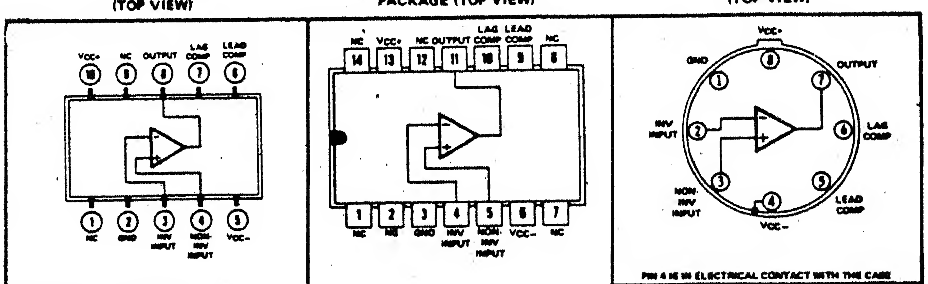
description

The SN52702A, SN52702 and SN72702 circuits are high-gain, wideband operational amplifiers, each having differential inputs and single-ended emitter-follower outputs. Provisions are incorporated within the circuit whereby external components may be used to compensate the amplifier for stable operation under various feedback or load conditions. Component matching, inherent in silicon monolithic circuit-fabrication techniques, produces an amplifier with low-drift and low-offset characteristics. The SN52702A is an improved version of the SN52702. These amplifiers are particularly useful for applications requiring transfer or generation of linear and non-linear functions up to a frequency of 30 MHz.

The SN52702A and SN52702 circuits are characterized for operation over the full military temperature range of −55°C to 125°C. The SN72702 circuit is characterized for operation over the temperature range of 0°C to 70°C.

terminal assignments

FA FLAT PACKAGE (TOP VIEW) | J OR N DUAL-IN-LINE PACKAGE (TOP VIEW) | TO-5 L PLUG-IN PACKAGE (TOP VIEW)



NC—No internal connection

15. When replacing soldered-in ICs on a printed circuit board, the technician should use the (largest/smallest) soldering iron possible with a (grounded/ungrounded) tip.

CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE LESSON TEST. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL OR MOST OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULT WITH THE LEARNING CENTER INSTRUCTOR UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

ANSWER SHEET FOR

PROGRESS CHECK

LESSON 4

Field Effect Transistors

QUESTION No.	CORRECT ANSWER	QUESTION No.	CORRECT ANSWER
1.	c.	6.	b.
2.	P, N	7.	d.
3.	increase decrease increase	8.	total electrical isolation source-drain channel
4.	large high reduced to zero	9.	b.
		10.	high, voltmeter
5.	MOSFETs JFETs bipolar transistors		

ANSWER SHEET FOR

PROGRESS CHECK

LESSON 1

Introduction to Linear Integrated Circuits

QUESTION No.	CORRECT ANSWER	QUESTION No.	CORRECT ANSWER
1.	many	8.	b.
2.	d.	9.	counterclockwise
3.	b.	10.	clockwise
4.	will	11.	c.
5.	do	12.	c.
6.	must	13.	in the middle
7.	a.	14.	a.
		15.	smallest, grounded

NOTES

NOTES